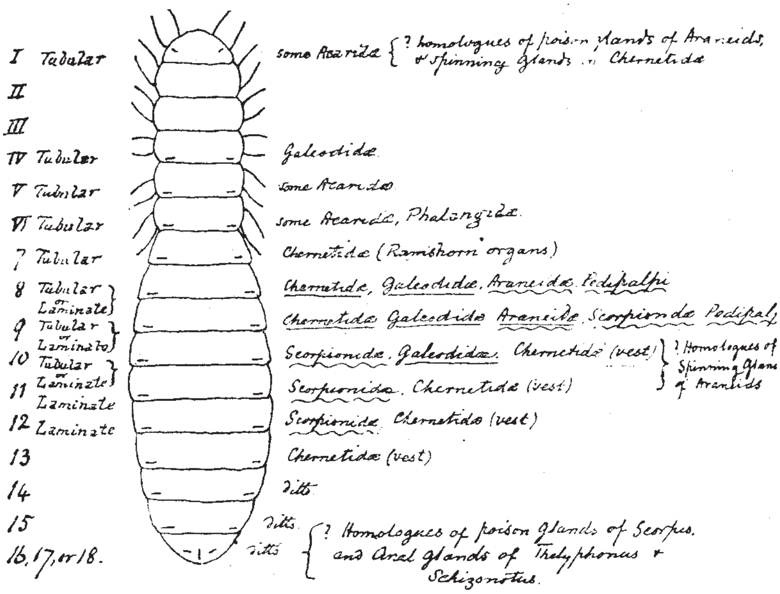
# THE STIGMATA OF THE ARACHNIDA, AS A CLUE TO THEIR ANCESTRY.

IF on a diagram of an Arachnidan body we mark every segment on which stigmata are said to occur, the result is somewhat remarkable.

The subjoined figure is such a diagram, and stigmata, functional or vestigial, are known on all the segments except the second and third. On the left hand of the diagram I have recorded the form which the tracheal invaginations from each pair of stigmata assume, *i.e.* whether they are tubular or laminate; and on the right hand I have noted the genera in which the stigmata occur, with a straight underline if their tracheæ are tubular, and a wavy underline if their tracheæ are laminate. The marks which represent the stigmata are not intended to denote their real positions on the segments, but only to indicate their presence, although there is reason for thinking that they may well represent their primitive positions.

On the first segment we have stigmata recorded *on the dorsal surface at the bases of the mandibles* in some Acaridæ. This remarkable position may be in in some way connected with the formation and dorsal arrangement of the "cephalic lobes,"[1] which accompanies the translocation of the mandibles from a post oral to a pre-oral position. All the other tracheæ of the Arachnida are associated with limbs, the Arachnida agreeing in his point with the Hexapoda and Myriapoda, but differing from the Peripatidæ.


I Tubular
II
III
IV Tubular
V Tubular
VI Tubular
7 Tubular
8 Tubular or Laminate
9 Tubular or Laminate
10 Tubular or Laminate
11 Laminate
12 Laminate
13
14
15
16, 17, or 18.
some Acaridæ { ? homologues of poison glands of Araneids, & Spinning Glands " Chernetidæ
Galeodidæ
some Acaridæ
some Acaridæ, Phalangidæ
Chernetidæ (Ramshorn organs)
Chernetidæ, Galeodidæ, Araneidæ, Pedipalpi
Chernetidæ Galeodidæ Araneidæ, Scorpionidæ Pedipalpi
Scorpionidæ, Galeodidæ, Chernetidæ (vest)
Scorpionidæ, Chernetidæ (vest)
} ? Homologues of Spinning Glands of Araneids
Scorpionidæ Chernetidæ (vest)
Chernetidæ (vest)
ditto
ditto
ditto
? Homologues of poison glands of Scorpio, and Anal glands of Thelyphonus & Schizonotus.

On the sixth segment we have stigmata both in Acaridæ and Phalangidæ behind the last pair of legs. This position may mean either on the last cephalothoracic or on the first abdominal segment. I do not wish to lay special stress on this one case; but, considering the general absence of stigmata on the abdomen in Acaridæ, owing to the rudimentary condition of this region of the body, I think there is something to be said for the position indicated in the diagram. The same argument applies to the Phalangidæ, in which animals also the abdomen is but feebly developed.

On the first abdominal segment (7) we have the remarkable ram's-horn organs which I have elsewhere[2] suggested may be a primitive form of tracheal invagination, from which either laminate or tubular tracheæ may be very easily deduced.

On the following two abdominal segments (8 and 9) we have tubular and laminate tracheæ equally distributed, all those hitherto described having been tubular.

On the tenth segment we have functional laminate tracheæ in Scorpio, tubular tracheæ descending to a medium (? closed) stigma in Galeodes, and vestigial stigmatic scars in the Chernetidæ. These scars are repeated segmentally on all the remaining abdominal segments in the Chernetidæ, and represent the closed stigmata of vanished tracheæ, which tracheæ, if we may judge from the ram's-horn organs and the functional tracheæ on the second and third abdominal segments, were all most certainly tubular.

From these facts we are justified in concluding (1) that the tracheal invaginations of the ancestor of the Arachnids were strictly segmental, and (2) that these invaginations were of some simple tubular type, from which the laminate forms could be easily developed. The ram's-horn organs of the Chernetidæ, with the simple air chambers in their epithelial cells as recently described (*l.c. supra*), might well represent such primitive invaginations.

An impartial review of the facts must convince everyone that the laminate form is the more specialised. The tubular form is by far the most widely distributed, being not only universal among the Hexapoda and Peripatidæ, but far more common among Arachnids than the laminate. Tubular tracheæ occur universally in the Acaridæ, which have some claim to be considered as fixed larval forms (*Jour. Linn. Soc. Zool.* vol. xxiv. p. 279); in the Phalangidæ, which are so specialised that they must have branched off very early from the main Arachnidan stem; in the Chernetidæ, which again are very difficult to class, and may claim to be an independent group; and lastly in the Galeodidæ, which in many respects are the most primitive of all Arachnids.

The Araneidæ, with their highly specialised abdomen, possess both laminate and tubular forms, while the Scorpionidæ and related Pedipalpi are the only Arachnids, and indeed the only Arthropods (except a few Myriapods), which have exclusively laminate tracheæ. The laminate tracheæ of the Myriapods cannot possibly be deduced from the laminate tracheæ of the Arachnids, but both forms of laminate tracheæ can be deduced from a primitive tubular organ.

Returning to the diagram, the facts therein epitomised presuppose the existence in the ancestor of the group of simple limbs on every segment. In addition to the six pairs of limbs on the first six segments, clear traces of limbs are well known either in a persistent or a vestigial disappearing form on the first six abdominal segments. Further, we can conclude from the stigmatic scars on the Chernetidæ, that there must originally have been limbs on all the remaining segments of the abdomen. The character of these limbs may perhaps be gathered from those of the nymphs of many Acaridæ, which probably represent the earliest developmental stages in the Arachnida now traceable, and perhaps also from the legs of the Silurian Scorpion, *Palæophonus nuncius*.

We can thus trace the Arachnids back to a segmented ancestor with a pair of limbs and a pair of tracheæ on every segment—*i.e.* to an ancestral form resembling those of the Myriapoda and Hexapoda, but differing from these in having the rows of stigmata ventral instead of lateral, apart, of course, from the profound difference in the specialisation of the oral appendages.

Among the later modifications of this primitive Arachnid we have the differentiation of the body into the cephalothorax and the abdomen. The former consists of the first six segments which have retained their limbs. The segments of the latter have lost their limbs almost completely, rudiments, however, persisting as genital opercula, pectines, and spinning mammillæ. In the former the great development of limbs and musculature and the fusing of the segments together has led to a general suppression of the tracheal invaginations. One pair, however, persists in the Galeodidæ, *which, with the exception of Schizonotus, are alone among Arachnids in retaining the original jointing of the posterior cephalothoracic segments*, and in the Acaridæ and Phalangidæ, in both of which the abdominal region is not fully developed.

The second and third segments appear to be the only ones on which hitherto no traces of stigmata have been found. This may be due to the fact that in the formation of the mouth parts the first three segments early fused together.

The general disappearance of tracheæ from the cephalothorax

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[1] "The 'Head' of Galeodes," &c. *Zool. Anz.* No. 426, 1893.

[2] "Notes on the Chernetidæ." *Linnean Society's Journ.* (in press).

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necessarily confined the respiratory organs to the abdominal region. Further, those on the anterior segments of the abdomen would be gradually preferred for specialisation, as being nearer to the cephalothoracic musculature, and to the shelter of the limbs for the protection of the open stigmata. The Scorpionidæ alone, having highly developed musculature in the posterior abdominal segments, have the respiratory invaginations nearly evenly distributed along the middle of the abdominal region.

On the diagram I have further indicated a few suggested homologies. I have elsewhere[1] brought forward evidence in favour of the derivation of tracheæ from setiparous glands. The derivation of poison and spinning glands from similar structures is generally admitted. The consequent homology between the spinning glands and tracheæ requires a slight modification. When, as in the Hexapoda, most Myriapoda, and the Arachnida, the tracheæ are strictly segmental, and intimately associated with limbs, they have probably arisen from the large bristle sacs which secreted the specialised parapodial acicula; spinning glands, on the other hand, are more generally to be deduced from groups of ordinary bristle sacs, although they may also be deduced from acicular glands as well. It is important to bear this qualification in mind, as it helps to throw light on a difficult point in the morphology of the Araneids. While the two pairs of spinning glands on the two pairs of mammillæ are referable to setiparous glands on rudimentary limbs, and probably homologous with tracheæ, there are also, in the majority of spiders, median spinning glands between the mammillæ, which cannot be brought into connection with any rudimentary limbs. This difficulty is, however, fully explained by the position of the abdominal cement glands in the Chernetidæ, which serve to stick the eggs to the abdominal surface, in which position they are carried about by the parent. In these animals we have, on the second and third abdominal segments, median glands (originally paired) occurring *between* the two pairs of tracheal invaginations. In this case I should refer the tracheæ to acicular glands, and the cement glands on the same segment to groups of setiparous glands lying ventrally to the acicula. In the genus Galeodes, rows of short powerful bristles actually occur in the corresponding position, *i.e.* close to the median line on the second and third abdominal segments, and form the stigmatic combs, which are quite distinct from the stigmata themselves. According to this derivation we might have two pairs of spinning glands on each segment, one pair placed laterally on mammillæ, and one pair close to the median line between the mammillæ. This arrangement is actually found in the rare spider Liphistius, which has four pairs of spinning glands arranged as here described. This is especially interesting, because in addition to other primitive features Liphistius is alone among known spiders in retaining at least nine distinct abdominal tergites.[2]

The facts and suggestions here briefly set forward are a small instalment of the results obtained during my researches on the comparative morphology of the Galeodidæ, which I hope shortly to have ready for publication. I may, perhaps, add that the net results of these investigations go far to establish that classification which ranks the Arachnids as an independent group of the tracheate Arthrpodos, as distinguished from that which would deduce them from the specialised Crustacean Limulus through the specialised Arachnid Scorpio.

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## THE PRESENT STANDPOINT OF GEOGRAPHY.

MR. CLEMENTS R. MARKHAM, C.B., F.R.S. inaugurated the evening meetings of the new session of the Royal Geographical Society, on Monday night, by a presidential address on the present standpoint of geography. He gave a survey of the state of our actual knowledge of the earth's surface, and pointed out the regions where exploration may still be done. Viewing exact delineation by trignometrical measurement as the crowning work of geography, he pointed out how incomplete the exact mapping of the land surface of the globe still was, while the delineation of the bed of the ocean had hardly been begun. In the Polar regions, of course, lay the greatest unknown areas, and the two expeditions now in the field, Nansen's and Peary's, were referred to with some confidence as to their probable success. Mr. Markham himself believed that land exists between Prince Patrick Island and Siberia, which ought to be discovered, and was inclined to accept Lieut. Hovgaard's theory of extensive land north of Cape Chelyuskin. He indicated the delineation of the north coast of Franz Josef Land as one of the more important pieces of Arctic work for the near future. Consideration of the vast Antarctic field was postponed until Dr. Murray's paper at the next meeting.

In Europe there remained scope for detailed survey in many countries, and Mr. W. H. Cozens-Hardy's recent labours on the frontiers of Montenegro are only a foretaste of what has to be done in the Balkan Peninsula. The Cantabrian mountains on the west, and the Caucasus on the east, contain still many isolated unknown patches.

In Africa the unknown had been diminishing within his memory more rapidly than anywhere else, and the days of suddenly-planned expeditions discovering features of the first magnitude had altogether passed. What remain unknown are two great areas in the Sahara, in the Tibesti, and Ahaggar highlands, the negro kingdom of Wadai, and the region stretching from Southern Abyssinia into the Somali Peninsula. In countless places detailed work has to be done, such as Dr. Gregory's study of Mount Kenia, and Mr. Scott-Elliot's similar detailed survey of the Ruwenzori region, just undertaken. The best future work for geography in Africa lies in surveying rather than exploring, and lines of survey should be run across the continent in defined and well-thought-out directions.

Asia has also new ground to break into. The valleys of Hadramant, in Arabia, are almost as little known as the Antarctic regions, and Mr. and Mrs. Bent will shortly endeavour to explore that district. In Asia Minor and Persia much detailed surveying must be done. In Central Asia there is Lhassa, unvisited by an Englishman for generations, and a vast region in north-western Tibet, between 34° and 36° N., and 82° and 90° E. is a blank upon our maps, in spite of the magnificent journeys recently made by Bower, Rockhill, and the Russian explorers. Nearer India, Nepal is little known ; Kafiristan is absolutely secluded from the European, and there could be no nobler ambition for a young geographer than to be the first to explore Kafiristan. The maze of mountain ranges and river valleys east of the Himalayas has yet to be unravelled, and the whole interior of Indo-China is full of opportunities for research. Korea, in the far east, is yet far from being fully known. The great Malay Archipelago must receive much more attention, and the problems of western New Guinea alone, with the grand range of the Charles Louis mountains, are well worthy of being seriously attacked. Upraised coral atolls in the Solomon Islands have been reported but not visited. As regards new discovery, however, there is probably no undiscovered islet remaining in the whole Pacific.

Australia, except some desert patches in the west, has been practically explored, although immense areas have still to be surveyed, and the development of colonial geographical societies gives good promise of that continent being thoroughly studied from within.

In North America, Dr. George Dawson enumerates a number of great stretches of land, aggregating several hundred thousand square miles, absolutely untraversed by any intelligent white man. These lie mainly north of the Arctic circle, between the great rivers that flow into the Arctic Sea and in Labrador. Alaska also has its unknown tracts, and even in the United States there is much room for detailed surveys.

Central America is not well known, and in South America much of the Colombian Andes, the basins of the Japura and Putumayo, the whole tract between the Andes and the Orinoco and Rio Negro, are practically unknown. In Peru whole provinces are unexplored, and many peaks unmeasured.

Oceanography is only beginning to yield results, and other departments of generalised physical geography are of growing importance. The better instruction of intending travellers, inaugurated by the Society, and carried out by Mr. Coles, has done much to confer value on the observations of officials, traders, and missionaries, while the more thorough study of theoretical geography, now beginning, requires great extension and elaboration before its work would be thorough.

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[1] *Zool. Jahrb.* vol. v. p. 511, and *Ann. and Mag.* January, 1893.

[2] *Cf.* "Liphistius," R. I. Pocock, *Ann. and Mag. N. H.* October, 1892.

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